Building a Collaborative Biomedical Network

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So, let me really give you some observations from the perspective of where I stand. I think the country really is truly at a turning point now with regard to healthcare and healthcare reform. I think an overriding concept we need to really accept is that the health of an individual is really co-dependent on the health of the entire community. I think another sort of interesting thought is health is not just healthcare. And then healthcare itself is not just health insurance. These are kind of interesting and strange concepts, as you go through understanding this healthcare system, which we call a complex adaptive system. I really believe there's truly a need to apply what are called the signs of healthcare delivery. These are sort of strange terms that we're going to try and get through today.

I thought I would share with you—this is a slide I actually put together in 2006, when I had the honor of being invited to Denmark to speak to the Novo Nordisk Foundation. It was as we were trying to actually establish our own Chan Soon-Shiong Family Foundation; of how did the Novo Nordisk Foundation, how did Denmark, and how did they do their good works with regard to healthcare? This particular slide was from when I was asked to give a keynote then, and this complicated multiple slide and multiple thoughts hasn't changed, actually. There really is an urgent need to change a paradigm of healthcare from an empirical, what I call empirical as a physician, qualitative system—we really don't really have a real idea of what we're doing when we're actually treating a patient—to a predictive, quantitative, evidence-based outcomes-driven care, which I think we have a true opportunity to change.

In order to do that, I really believe we need to take what I call convergence. There really is an opportunity now to rapidly implement the convergence of basic science, translational sciences, clinicians and bioinfomaticians for the next generation of therapy and quantitative medicine. The good news is, I really believe there's not only a moral and economic imperative to provide equal access to the highest quality care of all. I think this country, unlike any other country in the planet, can do that, and frankly, for us to export healthcare and innovation as a foreign policy.

So, this is the slide that I put, and this basically is in fact, and the reason I brought this slide back up, the theme of this day's talk, where I really believe we have an unsustainable healthcare cost. We have truly a non-system of care. But most, I think, depressing to me as a physician and a scientist is the absence of real-time cognitive objective decision support and actionable data for evidence-based personalized medicine. The entire talk that Ken gave is right on point. There really, therefore, is an urgent need for a comprehensive solution, which requires

the integration of care and secure information exchange on a national scale—what I call the national informational highway. We've had the interstate. That changed the country. Railroads changed the country. Telegraph, telephone changed the country. I think this is going to change the world, if we indeed have an opportunity to have this information exchange.

Now, a lot of my talk will go right down to the real world to the community doctors. It's wonderful that we have this community here, but at the end of the day, these are the patients we need to focus our efforts on: in which 5 percent of the patients incur 55 percent of our healthcare costs in terms of high-risk, multiple disease, complex and intensive care. It is our goal and our vision to change this, because no country, no healthcare system will ever now be able to stain these expenditures without early detection and true prevention. If you look at that, the only way to address this is to have what Ken has described as this integration of care. Frankly, I've never seen these slides, he's not seen my slides, and it's quite remarkable how you can see I even present I-SPY 2 here, you'll see. So, you begin to see the needs at the end of the day go to the real world claims treatment, labs provider and can get into what are called predictive modeling in evidence-based matters and stratification.

So, how do you bring the sort of high-faluting big ideas down to the clinical physician who's trying to literally keep his doors open, pay for the secretary, and keep the paperwork going? That's what faces the real world there. There are 130 million Americans suffering from chronic conditions. Medicare population has doubled between 1992 and 2002, and a remarkable statistic is that by 2230, there'll be 360 million diabetics worldwide, and one in three people will have chronic kidney disease.

So, how is this sustainable and how do we have what we have now if we indeed take this concept that chronic disease is an epidemic? If you take the whole idea that, in fact, we're dealing with an epidemic—and one of the best papers that I've seen written is this whole idea of epidemic science in real-time, which Harvey Fineberg just published this in 2009—and we have this massive inability not only to measure outcomes but to really focus on epidemic science. His opening statement, "Few situations more dramatically illustrate the salience of science to policy than an epidemic," and for example, the whole flu epidemic, in 1918 and 1919, where they gave the flu shots, and nine months later, despite the fact that not a single [raid] case were infected. So, the decision-makers then, according to the paper, failed to take seriously the question: what additional information could lead to a different course of action? The answer's precisely what should drive your research, in real-time today. I'll come back to that theme of what additional information could lead to a different course of action.

If that is the issue to us—what additional information could lead to a different course of action, in terms of our system of healthcare—unfortunately we have a non-system of healthcare. And this is George Halverson: "At best a non-system of care, and truth be told, current non-system of care is inconsistent, massively expensive, sometimes dangerous, operationally inefficient, and dysfunctional and sometimes perversely incented. Otherwise we have a great system."

I think that's what we're confronted with, so let me now share with you our approach to try addressing this, and how today's meeting is so important to that approach. I think we need to truly recognize that healthcare is this complex adaptive system, and that there are three buckets, so to speak. There's this knowledge domain, and this knowledge domain, as you can see, is scattered, and sometimes integrated, and here you see these communities and located. Then there's this care delivery domain that's focused really on the patient. Then you have certain areas within, like the Geisingers and the Mayos and the Kaisers. In general, 80 percent of the care is in the community, scattered and discoordinated. Then you have the payer domain, which is totally without any rationality, frankly.

So, you have these three domains. Now what's problematic is you have these ways of saying: has anybody looked at these three domains in a systematic view? If this is a complex adaptive system, one needs to look at it totally as a systematic view, and you have these interfaces. From the knowledge domain to the patient, we have this translation of care, as you've been shown, when the breakthroughs are being made. Now at the RAND it's been shown that from the time a breakthrough's made to the time it's actually adopted is 17 years. That is not only totally unacceptable, especially with the whole molecular profiling. We need to now have a much more rapid translation.

Now when you get into the care delivery domain, and if your job as a doctor is to keep a patient healthy, there's actually no way to get paid for keeping a patient healthy. The only way you get paid is when you actually get the patient into the hospital and do as many things as you can. That's the only way to get paid. So, that's all messed up and backwards. This is what we're faced with. Therefore we need to say we have within this knowledge domain this magnificent opportunity to take advantage of 21st-century molecular-based personalized medicine, to totally reclassify all diseases, and particularly cancer, into its molecular state.

We need to figure out a way very rapidly to bring that information to the patient. Now I really mean to the patient—at the patient's home—and to coordinate and integrate this care and deliver what we call evidence-based medicine. So, now we're talking about the general practitioner, the oncologist; not the learned third Mayo clinic and Sloan care treatment and the MD Andersons. Really, how do we get this down to the patient? This means that we have a need for a whole new science of what I call healthcare delivery. Now when we get it to the patient, we need to keep the patient out of the hospital. We need to keep the patient healthy. So we need to pay for value; i.e. lower-cost, better outcomes, and safer, better access. Therefore, we need a whole new model of payment and next-generation payers' intermediary. We found a way in which we said, "We need to go do this,"; where we need to get rapid transfers and create this learning system and have a payout for a different level rather than this reimbursement for a procedure. This is what we've now created—a 501(c)3 organization, the Health Transformation Institute, which is going around the nation right now trying to adopt real models to execute this.

Let me now take the rest of the talk to give you some detail of some little pieces of this, and I hope I can do this as rapid as possible, because there's a lot of slides coming up next. Let me talk about what I believe about the knowledge domain – and is so pertinent to you. Here we have how we treat patients today. We actually truly just guess. We give a drug, switch a drug, switch a drug again, and now we have this information overload. This is a Mayo slide, where less than one percent of information is applied to the MD at point of care. That's crazy. Less than one percent of information is applied to the patient at point of care. And the reason is this cognitive overload. I mean, we can hardly keep up, and here this is what we do: what molecular subtype, what dose, what schedule, what stage? Let me give you Avastin, for example. This is Avastin, and this is how Avastin works, and it became a blockbuster, a billion dollar drug. So, guess what? Pharma follows, and there's a whole venture of drugs, and these are the targets, and where's the target? Which target?

This is a very important slide that was presented at IOM in Bullstead. When we were in medical school, we had 10 facts to make a clinical decision. By 2020, 2010, we'll be up to 1,000 facts to make the appropriate clinical decision. The RAND study has shown that if you actually see a doctor today, the chance that you can get the right treatment is 45 percent. Can you imagine a flip of a coin? That's what we're facing, which says that we really need to figure out a way to get the right decision, right time, right patient, and right place.

Now you may say, "Well, this is sort of nice and theoretical." Let me show you real time. This is what really has driven what we do now in our family foundation. This inability for practicing physicians to maintain pace with the rapidly evolving field has real-time implications. Let me show you some anecdotal examples. The implication is that the doctor can't keep up. This last question I just said, the epidemic science, is what additional information could lead to a different outcome if in fact we knew the information? Here, for example, is the sentinel node theory that has actually been developed with John Wayne Cancer Center and published in *New England Journal of Medicine* and has changed the course of the practice of medicine- i.e., you go ahead, and you find a positive sentinel node, and you give the patient chemotherapy. You change survival. Having said that, in breast cancer, here the woman is getting this wonderfully sophisticated treatment of having dye injected into her arm, the underarm surgery and the nodes removed, and you have lymphodema. There are now whole support groups for lymphodema, where you survive your breast cancer, but for your life, your arm is swollen. And wouldn't it be wonderful that we now know, in fact, that these tumors actually secrete DNA into the blood? Therefore, wouldn't it be wonderful if you had a serum DNA integrity test? All these patients here could avoid their surgery.

Amazingly, this is published in JCO, a bunch of community oncologists said, "How many of you use sentinel nodes?" (raises hand) "How many of you know there's, in fact, potentially a blood test?" None. And not because they're bad doctors. They could not keep up, and this test is now being validated. Would you as a patient, want to know—if I had that test, and it was positive, I don't need to

have that surgery? I'm going to have chemotherapy, in an adjuvant setting anyway.

Pancreatic cancer—this is an ad board I held in ASCO, and I asked Malcolm Weir, one of the foremost scientists and the whole ad board, to talk about pancreatic cancer. As you said, standard pre-cancer, they just did pancreatic cancer these very famous people who died of pancreatic cancer. This is his slide. Regardless of stage, we suck at treating pancreatic cancer. So, would it not be interesting that in fact if you had distant metastasis—and I highlight distant metastasis—if you have the metastasis throughout your body in pancreatic cancer, your lifespan is average two months. So, would it not be important for you to know that if you have a patient with a lifespan of two months, that there's a potential for them to get into a clinical trial? If that patient was stratified inappropriately and got into this clinical trial and got the right treatment rather than the inappropriate treatment, then there will be heroic treatments given to these patients; there's a possibility that this patient, with his wide-spread PET scan, and the data to 7/3/2007; after having a patient spark positive, and after a single cycle or two cycles, would have a complete response. Would this not be wonderful to know of this trial? And in fact, here's another patient, complete response. Here's a third patient, complete response. So, which groups of patients are we talking about? This is important as you for a physician to know: this patient is in fact.

As it turns out, there's this whole protein called SPARC, and this is our work, so it's a little important. Again, I take the same smacks on this table here by talking about our own work, but I think this is so important that there is an opportunity for patients with a secreted protein acid-reaching cysteine—which is what SPARC stands for—if they were SPARC-positive patients, these are patients who have fully metastatic disease throughout their body, not locally invasive. Now we're getting median survival over 21 months in pancreatic cancer after just Gencytobene and this drug of Abraxane. I presented this provocative hypothesis—and again, this is my hypothesis if I call it provocative—in which a primary tumor from SPARC negative becomes metastatic when it becomes SPARC positive, and it gives us at least some insights to think about. I'm not saying this is the basis. A molecular basis of the mechanism of metastasis—and I presented this to the Pancreas Ad Board and I'm just going to go through this rapidly—but really the idea is that when you remove the blood supply, when you actually outgrow the blood supply, you have hypoxia and stress, and hypoxia and stress initiates SPARC. This, I believe, is the spark—ironically, no pun intended—of metastasis, because SPARC goes from a tumor cell into the stroma, and I believe releases these three events: reaction endogenesis, enhanced nutrition transcytosis, enhanced mobility, and, without going into the details, induces VEGF, and it induces this whole enhanced transcytosis, increased albumen secretion, and you now have metastasis. We take advantage of this biological pathway by driving the albumen protein drug into this environment.

Now, how would a practicing physician know about this? Now the most disconcerting, if you look to the top there where it says "Poor Vascularity and Antigenic Agent." If this were true, then in fact, if you were a patient and all you got

was a Novastin as a single agent, could you in fact induce metastasis when you have a primary tumor? That's a scary thought. And in fact, this becomes even more concerning after reviewing a paper published in *Cancer Cell* in March 2009 about accelerated metastasis after short treatment with protein inhibitor of tumor angiogenesis. The dogma of starving the tumor could in fact be wrong under certain circumstances.

In yet another, phase III melanoma trial which retrospectively looked at biomarkers, the patient with two biomarkers was dead in six months. The patients with zero markers were alive after 48 months. These were all the same patients in the same trial looked at with—so the trial made no sense, but there was no way of knowing this unless you actually got into these biomarkers.

Similarly, with colorectal cancer, there's a genomic profile,—all these patients responded or all these patients didn't respond—why should we give these patients who didn't respond these toxic drugs why should we not super-select the patients that do respond?

So, you begin to see these are real live examples talking about what we need to do today to actually help the practicing physician, and I believe we really have a call to action for quantitative predictive, preventative medicine.

Now let me talk to you about what I consider the future, which in fact, is here. If indeed we need to take the basic research clinical trials and clinical practice and blur, it really needs today to be blurred. If you were a patient today, you would want to actually receive something in today's therapy rather than 20-year-old therapy. The problem is we need to give data cross-processes where the basic reach of clinical trial or clinical practice across organizations, between pharmaceutical, scientific firms, cancer physicians, FDA, NCI, and then when we're facing with this data revolution, as Ken has just presented to you, we now have over 200 billion data points with the sequencing revolution. I truly believe we've solved as a nation the problem with the sequencing issue. What we've not solved is this torrent of data. How do you make this information clinically actionable?

And now this is UC Santa Cruz's work, where there's glioblastoma—as I said, we talked about this, and looking at this when you do the whole genome plot—now the whole genome plot is actually here now. The whole tumor genome plot is actually here, but on the left-hand side, you see this unfiltered mess of data, of which 98 percent is noise. Now that's scary. 98 percent is noise, so we need to actually take it to this on the right-hand side after an algorithm called "bam bam," where we actually end up with some clarity so that we can make this information clinically available. Again this is David Haussler's work where the tumor genome again through this "bam bam" pathway can now look at the number of copies in the tumor, of rearrangements in the tumor, and of deletions and mutations.

What we really need to get to, now that we're going to be at whole genome sequencing is the ability to process this raw data and take both "bam bam" and PARADIGM, and I'm rushing through that, but these are magnificent algorithms

that they've developed into what I call the health cloud. So we can take through the "bam bam" sequencing analysis, have sophisticated mutation calls, high-resolution copy numbers, breakpoint discoveries, and create a real patient-specific browser so we can actually look at both, most importantly, the mutations and gene annotations. But more importantly, that is just the beginning. On the left-hand side, you begin to see …This gene copy is just the beginning, and really where we need to go next is the expression state, the protein level, and protein activity, because as Ken has shown, at the end of the day, what we really need to look at are the protein networks.

So, how do we get there? We need to go from the patient's data looking at the mutations, copy number, expression all the way down to inferred protein activity in the pathway context and look at high-level interpretation. What's exciting is what you get from the inferred, we're actually able to get to the actual quantitative—and I'm speaking of an organization right here in DC—expression pathology that has made, I believe, some breakthroughs in which they've taken paraffin section tissue here and done micro-dissection and through liquid processing and mass spectroscopy now have taken this data and created protein analysis at attomolar level in liquid sections—and showed that in fact using this new quad—spectrometers—really can actually now measure proteins at the femtomole and attomole levels. Here's a rhabdomyosarcoma where again, truly at an atomal level, they've measured quantifiably the proteins, so now we can really validate the proteomics.

So, the idea then is we can truly have this clinically relevant genomic characteristic where patient data and genomic data, which is now converted into proteomic data, make up what I call a "wisdom database" so that a qualified molecular biologist, the practicing physician, and the patient all in real-time at point of care can understand this information as it affects the outcome, and the goal of this targeted cancer treatment. Ultimately what's most important is the ability to validate, and validation is really going to be key to as we proceed now using these algorithms, and here's your I-SPY 2 adaptive trial that Laura Esserman is beginning, and this truly is revolutionary. Well, I believe we need to induce the pharmaceutical companies to understand that we need next-generation innovation where we need to create a drug exchange, where the drug must find the patient, rather than the patient trying to find the drug. So, where we can take this whole basic research, clinical practice, clinical trials.

What we've done in Los Angeles, our very first foray with our foundation, is that we've created what I call the Bell Labs of Healthcare, and I'll share with you some of that. I truly believe that physicists, mathematicians, computer scientists, people working in engineering, biophotonics, nanophotonics are really going to make more contributions to healthcare than we as biologists can by using their tools to translate our work. We're using state-of-the-art tools as response predictors, so we have quantifiable clinical decisions and evidence-based treatments, and most important, we can share this information globally. At St. John's, we have an institute that is 26 acres run by eight Catholic nuns, and only Catholic nuns can accumulate 26 acres in Santa Monica. And it's surrounded by UCLA and USC. We've actually built this facility, which we think should be basically the beacon for

the country where collaboration will occur so that we can address 21st-century medicine.

Let me quickly now go into what I consider the science of healthcare delivery. So, we'll end up with ultra-large medical information systems, which I believe actually will be our most dangerous roadblock to personalized medicine—no longer the technological tools. We'll have this graveyard of data, which we need to create into this actionable information. We've done this at the national security level. They can do this. They can zap somebody. But we need to figure out a way to sort of do it in a better way with regard to a transformative healthcare system. I really believe architecture is everything, and so architecture's where we need to go. Distributed computing is where we need to go. Grid computing is where we need to go. And we've now tried to establish what we believe is a system using this particular architecture.

So, our very first foray into this was in California, at the California Telehealth Health Network, I'm proud to say is now standing. It's very exciting. We're going to link 800 institutions and maybe 2,000 institutions all the way down to the federal qualified safety clinic level to the major centers of the UC system. The FCC has given us money. We've just publicly stood up with the CTN, the California Telehealth Health Network, and tried to create that as the model of the nation, the largest intranet, so to speak, tied to CNet, tied to National LambdaRail, and tied to a virtual private cloud. And so we've also created this organization called NCHI, the National Coalition for Health Integration, a not-for-profit entity, and here are the centers that are about to be linked. And we believed through California and Arizona, we can begin this transformation.

Let me now talk about the coordination very quickly of delivery systems. And I gave some of this speech at the World Congress of Health, so I'm now stealing some slides that I actually presented there, but 1.8 million people went bankrupt despite having insurance, so it's not insurance. What we really need is an integrated health record, a health system where we don't have medical bridges to nowhere, where we really need to integrate and deliver most importantly information at point of care. So, you have a patient out in the Midwest trying to find a specialist, running across going across to, let's say, the West Coast, and there's no portability whatsoever—what I call those medical bridges to nowhere—which means we need to now address disruptive innovation.

Now what is concerning me? I'll just openly say. Disruptive innovation is disruptive not just because it's disruptive, but it needs to change the entire business models that come from [inaudible], whether it'll be farmers, whether it'll be large corporations, whether it'll be software developers. We need to now develop what I call the self-assembly of the human signal engine, and I'll explain what I mean by that. Molecular medicine has advanced to the pace exceeding our clinical utilization. That's a scary thought to all of us. Proteomics, metabolomics, plasmonics, nanophotonics are emerging fields that we are funding as our foundation. I'll show you some of the technologies that exist today. I believe that these technologies are the underpinnings of a self-assembled health record for all patients.

The other thing that must be disrupted is that effective healthcare can not only be delivered in a hospital-based setting, where less than 10 percent of the patients come for 55 percent of our cost. The new model must be sustainable, affordable, timely healthcare delivered in the home with integrated, coordinated community care through self-assembling health information at point of care anywhere, any time. How do we see that vision? Clay Christensen speaks to it well, by asserting that disruptive innovations win if in fact we really put our minds to it, and the Health Transformation Institute is going to go about this.

So, the first things I'll talk to you—I'm trying to give you some examples of patient-centered in-home clinical care—what I call the smart medical home. I'll talk to you about the smart medical bag. I'll talk to you about the continuous self-assembly of personal health biometrics. I'll talk to you about the whole real-time medication adherence, and I'll talk to you about some very exciting thing called Evoke Potential Capture of the mind-brain computer interface. So, I've got videos on all these.

Let me quickly walk through what I think we need to do. We need to re-design the delivery of care to real-time information on demand. We need to create, and I'll show you how we have, with 45,000 patients already having tried the smart medical home. And most importantly, through the cloud and through wireless—and I'll talk to you a little bit about a whole new technology called WiGig, where you can grab data 10 gigabits per second—and send this to the cloud so that we have this national medical information highway so that there's a smart medical call center where one nurse can manage 400 patients in an exceptional basis, real-time. That's being done as we speak, so that the care could really be integrated, coordinated, and continuous, whether it'll be primary care, specialty care, and then delivered in a new way.

So, let me show you some quick examples of what the Institute has done. There's Bluetooth WiFi, the remote patient monitoring. Now these FDA-approved devices: glucose, blood pressure, body manager—i.e scale—which now goes into the health cloud and through a 3G and 4G connection to clinicians—and so at the end of the day, the mobile device is going to be the way. So, this smart medical home is now being developed throughout California. We developed it again in Arizona. It's actually being developed in places like Taiwan and Singapore. In Singapore, most homes have got 1 gigabyte per second speed fiber optic, and we're a little bit behind in this nation. But the whole area of WiGig, and I'm going to give the WiGig keynote address in March—it's a whole new technology that now can supplant Bluetooth and will give you literally 10 gigabits per second. And this WiGig revolution is coming where quite literally you sync and go. You can actually have Avatar totally loaded in 11 seconds on your cell phone. I've seen the prototype. Again, with all due respect, we need to bring solutions that are affordable. Now clearly great things have been developed by Cisco, the HealthPresence and the Intel and Health Guide, but we are now at the next generation of wireless with the cost now to the patient is $100. This, I believe, will be a revolution—and we're about to deploy this, where the cost is

$100, where now you begin to see this device is being deployed in real peer-to-peer systems. It's now been applied in wound technology. [Video plays.]

So, this smart call center is quite literally running. As a result of this, they've shown a 71 percent decrease in amputations, and a 50 percent reduction in hospitalizations. We can then coordinate the care and actually have what I call the smart medical bag. There's a whole association called American Association of Housecall Physicians that does this. This is the patient that would've been in an ICU, and now for the first time, we have all the tools that I can literally have what I call ICU at home. And this is what's happening right now, and this is what's happening in local communities in California, and as I said, they've reduced the cost significantly. So, that's those two—first three—medication adherence and a taste of what's to be.

As I said, I really believe in physicists, mathematicians, electrical engineers, biologists interacting with aerospace engineers. Let me give you some examples of what I'm talking about. There's this whole science of independent component analysis, where I believe most of the signals we actually have in our human body literally can be captured, whether it be EEG signal, EKG signal, speech symbol, cyclic tumor signal, proteomic signal, metabolomics signal, and we need to really have what I call un-mixing and independent component analysis. Let me give you some examples just of speech, and I apologize if it's going to be loud, but you can hear this cocktail of noise. [Various audio files play in background.] If you put just the mathematics to it, you will be able to show how we can separate out each one of those, so that is what you hear. You put the mathematics to it, and that—now listen to the back of your ears. It's actually there. And that is actually there. So, that gives you some insight that one can now separate these signals, and in fact, we can even do this in language processing, so now we actually come to language processing, where we can separate these signals. We can take Spanish into English and English into Spanish, and this is two people speaking, but you can really—so there's a real ability now to have even language processing where a Spanish-speaking patient can actually speak Spanish, and English comes out on the other side.

The next use of this mathematical is really independent component analyses, it's ready for the first time now to set the mind-brain computer interface and the alpha, theta, and delta waves. And this was my first gift they gave to me, what I call the non-invasive central telemetry unit, where in fact, if you now take sensors for the first time that can actually measure brainwaves, send in Bluetooth wireless feed to the cell phone, we can quite literally see your brainwaves on your cell phone. And watch his eyes. As he closes his eyes, these brainwaves will change. So, all he's doing is sending those brainwaves, and as those alpha—and watch his eyes. As he closes his eyes, you're seeing a change in his brainwave pattern. As he goes into doing different motor movement, you'll see a change in his brainwave pattern. So, here he's doing motor movement, and he's changing alpha theta waves.

So, that technology of separating it out got converted to, as you see, this work is being done out of this country. And we can see now basically this mind-brain

computer interface quite literally now right-left movement has even now been developed, where the senses of the person going right or left, they can quite literally now play soccer games with each other, these two robots and these two people are playing soccer games against each other using the mind-brain computer interface. And I'll just let it run for one minute, because I think one of them wins this game. And there they go.

So, the idea is, well, with this communication control, what can we do with this? Could we do this in rehab? In fact, could we actually take this whole area now of the visual to evoke potentials? One could now actually take a paraplegic person, and convert this to all be totally wireless. And all he's doing is looking at the screen—and we've now put this on an iPad by the way—and each one of these numbers has a different hertz. And so if he wants to dial this number 13810443221, he would literally—and this is a paraplegic patient, say—look at the appropriate number and just let it talk its way through. He's quite literally looking at one. He then looked at three. [Audio file plays in background.] So, what's happening now is that we are now able to actually capture the waves, do the algorithm rapidly, instantaneously, convert that to Bluetooth, convert that Bluetooth now wirelessly to this device, and then dial the number and induce this cell phone to ring.

So, really the future of taking that now and creating an exoskeleton, which we're now working on, called 0G Exoskeleton, and letting the mind move the exoskeleton rather than the muscle, is really there. I was fascinated by what was presented me. We started drawing support to this group—of the whole area of this dyskinesia and how amazing the brain really is. So, this is a severe form of Parkinson's, and the patient's on dopamine overdose. And there's a whole area within the eye, within the brain that apparently gets stimulated and can totally reverse this non-invasively, called the blue lens. This patient is now putting on a blue and going right through to the retina, to the brain, and that's what happens to this patient the moment he focuses on the light. It's a remarkable transformation, which we're starting to begin to explore what is literally going on here. Here's a nurse. The nurse will bring this lens. He will take off his—and you notice immediately he begins to have his dyskinesia, as soon as he focuses on the signal—so this shows, really, while it's not as well-focused, so he still has some dyskinesia,—and really the power of the stimulation of that particular neuron or sets of neurons that is being stimulated to suppress. And in fact, as she moves this paper away, he loses control of the power within the neuron stimulation and reverts.

So, what we now begin to see—we really begin to understand at the single neuronal level, some insights, and so this—what I'm telling you about technology being here now—we just supported this first group right now at St. John's of being able to now do brain mapping and really require high-performance throughput brain mapping, so that tumors could be removed without doing a craniotomy. Large tumors are removed by actually navigating through the brain, and here's this large tumor. And you notice the patient's post-operatively craniotomy intact. We've now done 300 patients since November, discharged on average in two to

three days. I believe these are the kinds of advances that really could be done, and are being done.

So, with that, I really want to close by saying that I'm honored to be given the opportunity to present some of our work. I really believe that we must implement what I consider a convergence, and I think we have this moral and economic imperative, and we really have an opportunity, I believe, to close what I call this innovation gap in pharma using what Ken just presented here today, which is the whole idea of adaptive clinical trials. The thing that will prevent that will no longer be sequencing, no longer be the ability to do proteomics. The thing that will prevent that is information exchange and informatics and bioinformatics and what you do in this group and together as a nation. It's critically important, I think, to the next century. Thank you so much.

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